SINKING METHODS AND COSTS AT THE BURGIN SHAFT, BEAR CREEK MINING CO., EAST TINTIC PROJECT, UTAH COUNTY, UTAH

BY F. D. EVERETT

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SINKING METHODS AND COSTS AT THE BURGIN SHAFT, BEAR CREEK MINING CO., EAST TINTIC PROJECT, UTAH COUNTY, UTAH[1]

by

F. D. Everett[2]

SUMMARY

The Burgin shaft of Bear Creek Mining Co. near Eureka, Utah, was sunk during 1956 and 1957 as part of an exploratory program, searching for lead, zinc, copper, silver, and gold ore bodies hidden from the surface by several hundred feet of volcanic rocks.

This paper describes the sinking methods and operating practices of Centennial Development Co., contracting firm for Bear Creek Mining Co., in sinking a 3-compartment vertical shaft 1,100 feet. The operation featured the Cryderman positive-action, clam-type shaft mucker. The shaft was completed in 142 days by a shaft crew of 10 men and a top force of 10 men, including supervision.

INTRODUCTION

This paper is one of a series prepared by the Bureau of Mines on shaft-sinking methods and costs in various districts throughout the United States. The Burgin shaft was sunk as part of the exploratory program of the East Tintic project of Bear Creek Mining Co.

The Tintic district is in Utah and Juab Counties in central Utah, about 88 miles south of Salt Lake City. It is one of Utah's major metal-producing areas and has yielded ores valued at more than $400 million. Many of the mines have been either "worked out" or have been worked to such depths that costs are prohibitive, principally because of excessive pumping of water. The project is interesting in that it demonstrates a trend in exploration that is necessary to maintain and develop future mineral reserves.

ACKNOWLEDGMENTS

Acknowledgment is made to Harold Spencer, president, and James Quigley, vice president, Centennial Development Co., and Ray Gilbert, district geologist, Jack Bush, project geologist, and John Bader and Henry Fletcher, project engineers, Bear Creek Mining Co., for cooperative assistance in supplying data for this manuscript.

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PURPOSE OF SHAFT

The Burgin shaft was planned to provide access for exploring blind but geologically favorable areas in the East Tintic district, approximately 5 miles southeast of Eureka, Utah (fig. 1). Bear Creek Mining Co. has a long-term lease on several hundred acres of patented and unpatented mining claims in the area. The area was extensively studied before the project was approved; geologic mapping and surface core drilling was done in the early phases of the project. Geologists of the Federal Geological Survey investigated the area and since 1943 have used geochemical methods to study rock alteration.[3 4]

The objective of the East Tintic project is to find replacement ore bodies in Paleozoic limestone and dolomite beneath volcanic rocks that blanket the area. Studies in the area by the Federal Geological Survey indicate that rock alteration may be a guide to ore deposition. Mineralized limestone east of old mines of the district was found by surface exploratory drilling. Drilling by the Federal Geological Survey and studies of projected geologic structures and patterns of hydrothermal alteration partly determined the areas to be explored by the Bear Creek Mining Co.

The Geological Survey and the mining companies had previously found that surface drilling is inconclusive and unsatisfactory as a means of proving ore in the district. Bear Creek Mining Co. supplemented drilling information by shaft sinking, followed by crosscutting and underground core drilling.

The Burgin shaft (fig. 2) was named for William H. Burgin, Bear Creek Mining Co. district geologist, who was killed in a commercial-plane crash in 1955. Mr. Burgin was responsible for much of the preliminary work on the project.

As the result of competitive bidding by four companies, the contract for sinking the Burgin shaft was awarded to Centennial Development Co., a Utah corporation with offices at Eureka, Utah. Work on the project was begun November 12, 1956, and the shaft was completed to a depth of 1,100 feet, August 1, 1957.

The contract included constructing a hoist and compressor building and a changebuilding and office. It also required installing a hoist, compressor, lamp-charging equipment, water-storage tank, water heater, oil furnace, air receiver, and electrical substation; concreting the collar of shaft, the hoist and compressor foundations, the building slabs, and the headframe foundations; and sinking and timbering 1,100 feet of a 2 1/2-compartment shaft; and excavating for a 1,050 level station and loading pocket. The Bear Creek Mining Co. let the contract for fabricating and erecting the steel headframe to another company. Electrical and plumbing work and erection of the aluminum buildings were subcontracted by Centennial Development Co.

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[3] Lovering, T. S., Rock Alteration as a Guide to Ore - East Tintic District, Utah: Economic Geology Publishing Co., Monograph 1, 1949, 66 pp.

[4] Lindgren, Waldemar, and Loughlin, G. F., Geology and Ore Deposits of the Tintic Mining District, Utah: Geol. Survey Prof. Paper 107, 1919, 282 pp.

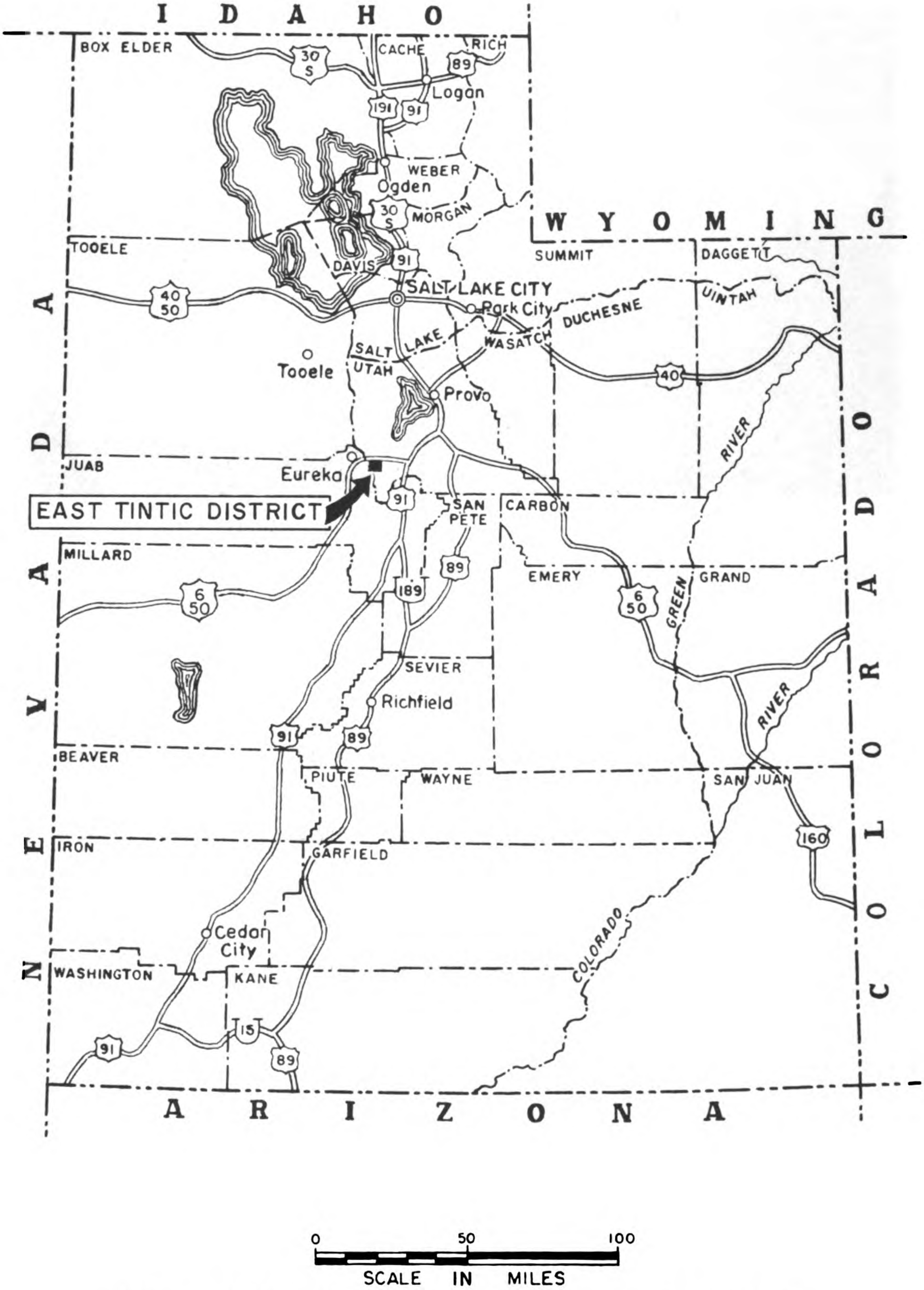

FIGURE 1. - Location of East Tintic Project Near Eureka, Utah.

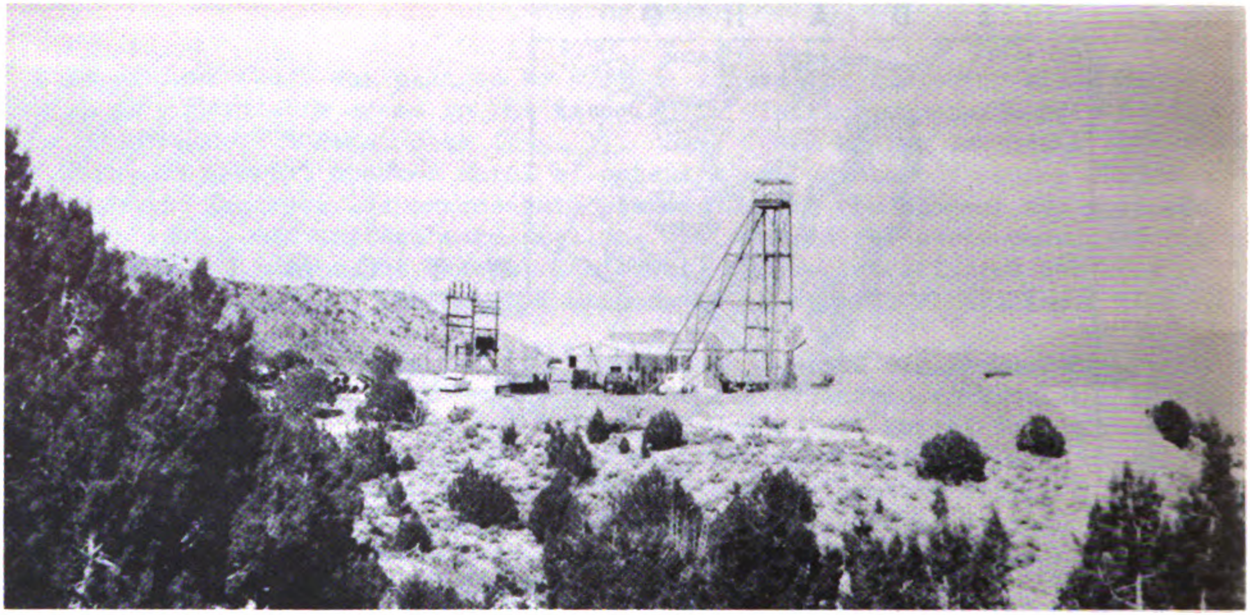

FIGURE 2. - Surface Setting at Burgin Shaft.

In July 1957 a contract awarded Centennial Development Co. included drifting and crosscutting from the 1050 level of the shaft.

GEOLOGY AND PHYSICAL CHARACTERISTICS OF ROCKS

The East Tintic district is on the east flank of the East Tintic Mountains. The west part is on the steeper slope of the range, which grades easterly into the broad Goshen Valley. The area has been extensively dissected by stream erosion.

The geology of the district is extremely complex; it comprises folded and faulted Paleozoic sedimentary rocks that, in many places, are covered by Tertiary lavas. In the main Tintic district the sedimentary rocks dip steeply, but in the East Tintic area the dips are more gentle and in places are almost flat. These sedimentary rocks consist of marine limestones and dolomites above the basal Tintic quartzite. The surface in the East Tintic district is covered with Packard rhyolite or other extrusive rocks, but some intrusive dikes of monzonite and quartz monzonite porphyry have been found, both on the surface and underground.

Most of the ores produced in the East Tintic district have been mined from replacement deposits in limestone. The principal ore bodies, containing lead, silver, and zinc, have been found in the Tintic Standard and North Lily mines. Pyritic copper-gold ore has been mined from veins in the underlying Tintic quartzite at these and other mines. The replacement deposits are commonly found in areas of shattered, jasperoidized limestone, usually at the intersections of low-angle faults and minor northeasterly crossfissures.

The physical characteristics of the rocks proved to be almost ideal for shaft sinking. In general, the rocks were hard, massive, and tough, with a minimum of fractures. The abrasive action of the rhyolite accelerated bit wear. Fragmentation after blasting was not as good as that in the limestone and dolomite. Only one major fracture zone was found, and it offered little trouble, except for water seepage. Occasional thin zones of shale and quartzite were noted below the rhyolite. The extremely hard quartzite required about double the average drilling time. Ground support was not a problem.

Shaft Site

The shaft is in the SE1/4SE1/4 sec. 15, T. 10 S., R. 2 W., Salt Lake Meridian, Utah County, Utah, 5 miles by road east of Eureka and 1 mile from the Tintic Standard surface plant at the No. 2 shaft. U. S. Highway 6 passes through Eureka and is 2 miles north of the shaft by road. Gravel and dirt roads provide access to the site. The altitude at the shaft collar is 5,635 feet.

The Packard rhyolite averages 700 feet in thickness and covers the surface. A hole had been churn-drilled near the shaft site earlier, and the geologic log of the stratigraphy for 1,100 feet was determined as follows:

Depth, feet	Rock	Depth, feet	Rock
0 - 10	Rhyolite.	720 - 830	Dolomitic limestone.
10 - 670	Porphyritic rhyolite.	830 - 850	Limestone.
670 - 710	Altered porphyritic rocks.	850 - 992	Dolomitic limestone.
		992 - 1,004	Quartzite.
710 - 720	Porphyritic rocks and dolomite.	1,004 - 1,100	Dolomitic limestone.

The factors considered in choosing the shaft site include:

(1) Proximity to the exploration targets; (2) probable absence of major faults; and (3) topography suitable for the surface plant.

SHAFT SINKING

Centennial Development Co. began work November 12, 1956. Preparation, including sinking the first 55 feet, was done by January 29, 1957. Active shaft sinking was begun January 30 and continued until completed on August 1, 1957. Work was continued on the shaft station and loading pocket and, under a new contract, on exploratory drifting and crosscutting.

Preparation

The preparation began by leveling the surface-plant site with an H.D. 5 diesel bulldozer and laying a 2-inch water pipeline for 5,000 feet between the shaft site and Dividend (Tintic Standard No. 2 shaft). This line was buried 3 feet at the shaft site and below the roads and railroad crossings but otherwise was laid on the surface. Surface excavations were made for building and equipment foundations and for pipe and electrical conduits. The surface-plant layout is shown in figure 3.

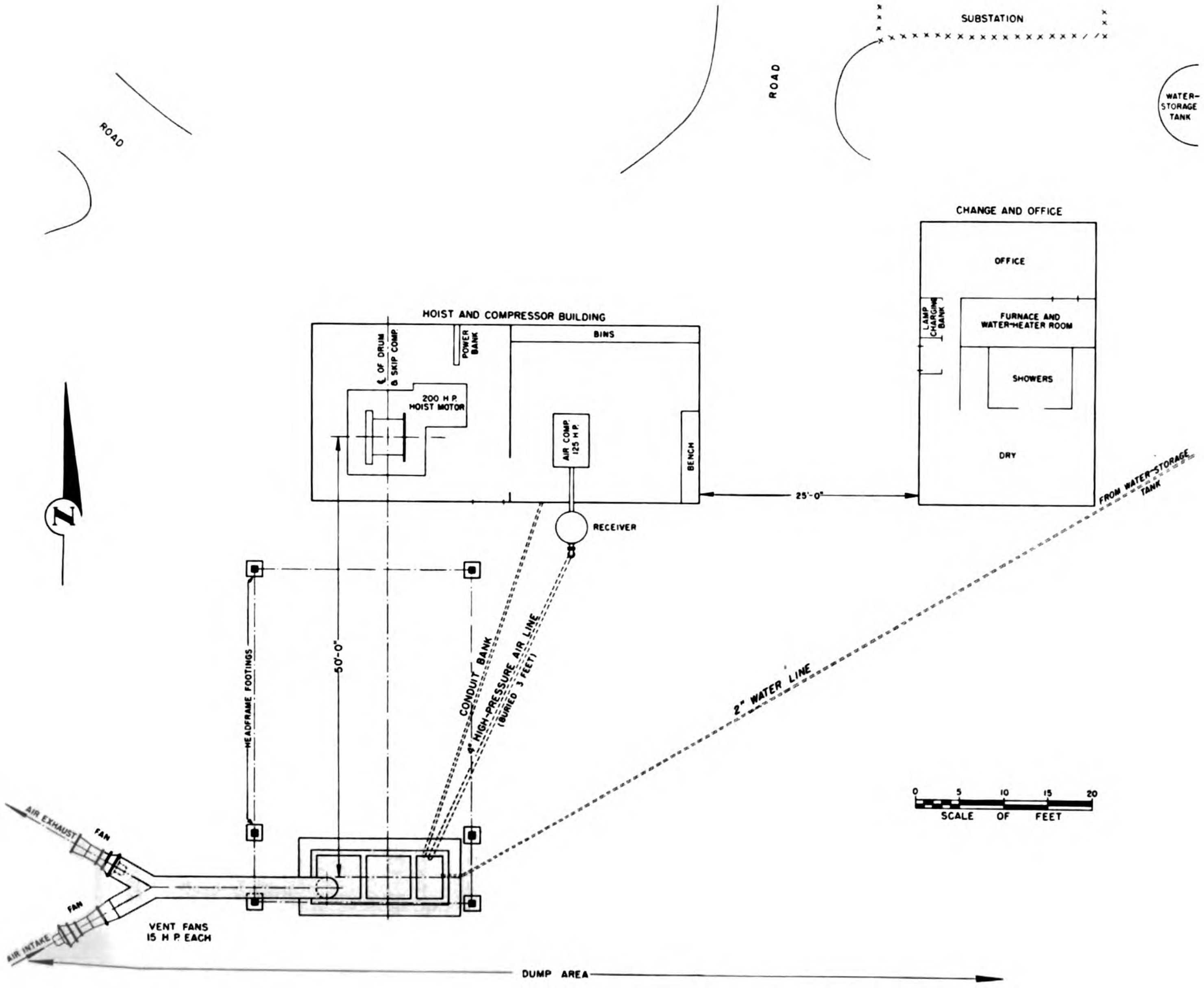

FIGURE 3. - Map of Surface Layout.

Insulated aluminum buildings were erected by a subcontractor to house the hoist, compressor, electrical panels, changehouse, and office. The installations for a 10,000-gallon water-storage tank, fuel-oil tank, septic tank, furnaces, waterheater, and heating equipment were also subcontracted. Concrete (5 1/2 sacks of cement a cubic yard) was transported 35 miles from a ready-mix plant in Spanish Fork, Utah. All concrete work contains reinforcing steel and was handled by the regular crew.

All electrical work was performed by subcontractors, including erection of a 750-kv.-a. outdoor substation. The electrical distribution system includes a 480-volt surface circuit, a 4,160-volt underground feeder, and a hoist signal arrangement; a 4,160-volt circuit breaker and control panel were installed in the hoist house. A charging panel for 15 lamp batteries was placed in the changehouse.

A single-drum hoist 4 feet in diameter and 3 1/2 feet in width is powered by a 440-volt, 200-hp., a. c. motor. The wire rope for the hoist is 1 inch in diameter and 1,536 feet in length. The maximum rope speed is 800 feet per minute. The air compressor has a rated capacity of 686 c. f. m. and is powered by a 440-volt, 125-hp. motor; it is in the room adjoining the hoisting installation and connected directly to an air receiver with a volume of 97 cubic feet. Air pressure is maintained at 110 p. s. i.

The shaft was sunk 55 feet with the aid of a 1/2-cubic-yard dragline shovel. The shaft collar was concreted to solid rock where the first bearing set of timber was installed. Concrete was placed 2 feet thick at the base and 1 foot 4 inches at the top (fig. 4). A 50-foot steel headframe was fabricated at Grand Junction, Colo., and required 4 days for erection. The sheave wheel is 4 feet in diameter. The center of the shaft is 50 feet from the center of the hoisting drum. The wire rope was connected directly to the 66- by 44-inch bucket. A crosshead cage designed by the company was supported by a torpedo clamp on the wire rope 8 feet above the sinking bucket.

The headframe was equipped with a steel dumping apron, actuated by an air cylinder and operated by the hoistman (fig. 5). A stopblock that was attached to the headframe and activated by the dumping apron stopped the crosshead cage and permitted the bucket to be lowered on the dumping apron (fig. 6). In the dumping operation an iron ball, on the end of a 3-foot chain attached to the bottom of the sinking bucket, was caught in a slot in the apron; as the bucket was lowered, it turned over and the muck emptied on the ground. The empty bucket was raised and the apron swung to a vertical position, allowing the bucket and crosshead cage to be lowered into the shaft.

Ventilation is provided through 30-inch-diameter tubing constructed of 18-gage galvanized iron. Flanges on each end of the tubing, constructed of 1/4- by 2-inch welded angle iron, are used to connect each section. A rubber gasket 1/8 inch thick separates all joints, which are connected by 12 3/8-inch-diameter machine bolts. On the surface the vent tubing branches into 2 segments, and in the end of each a fan is directly connected to a 15-hp., 440-volt motor (fig. 7).

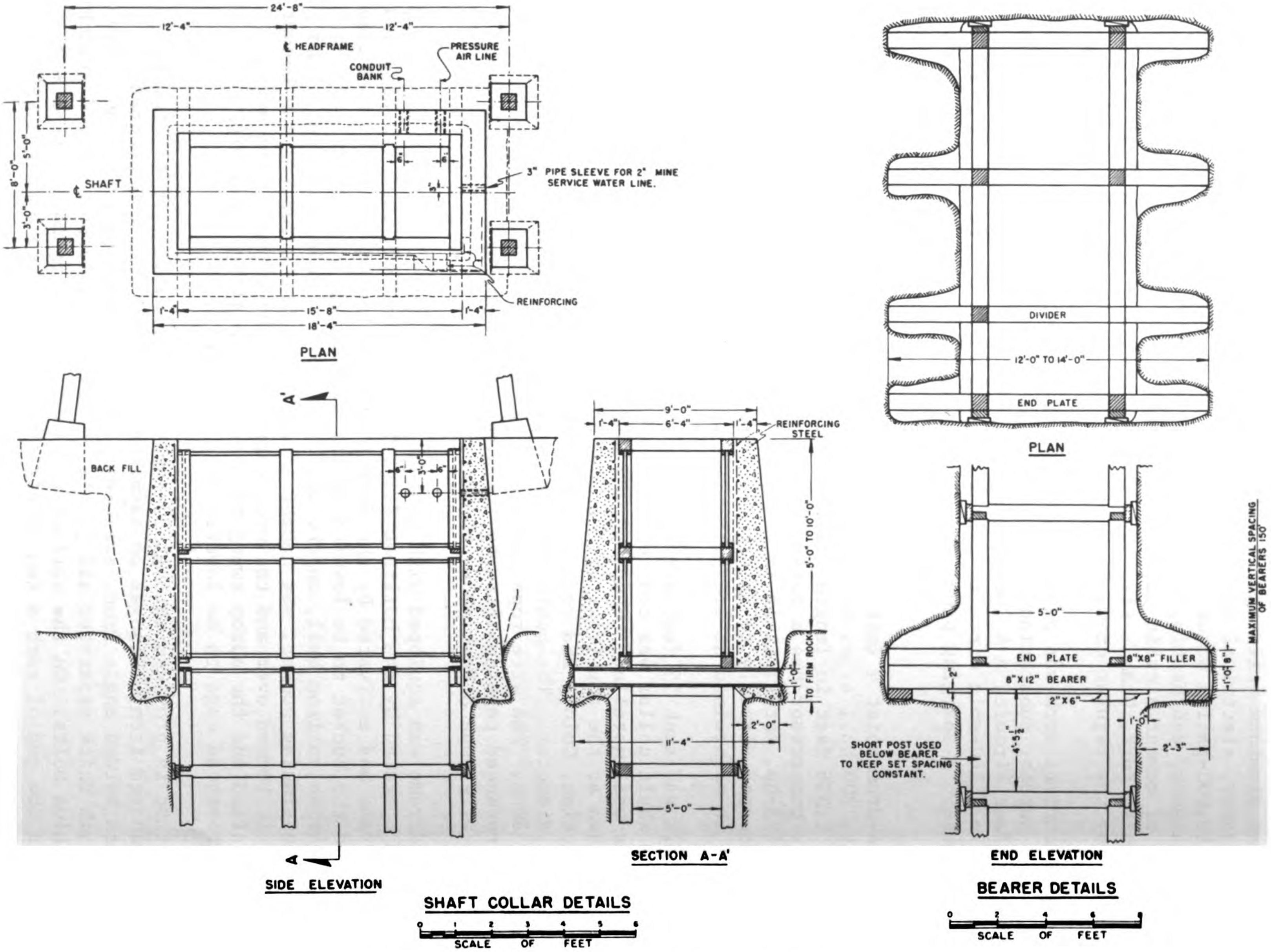

FIGURE 4. - Shaft Collar and Bearing-Set Details.

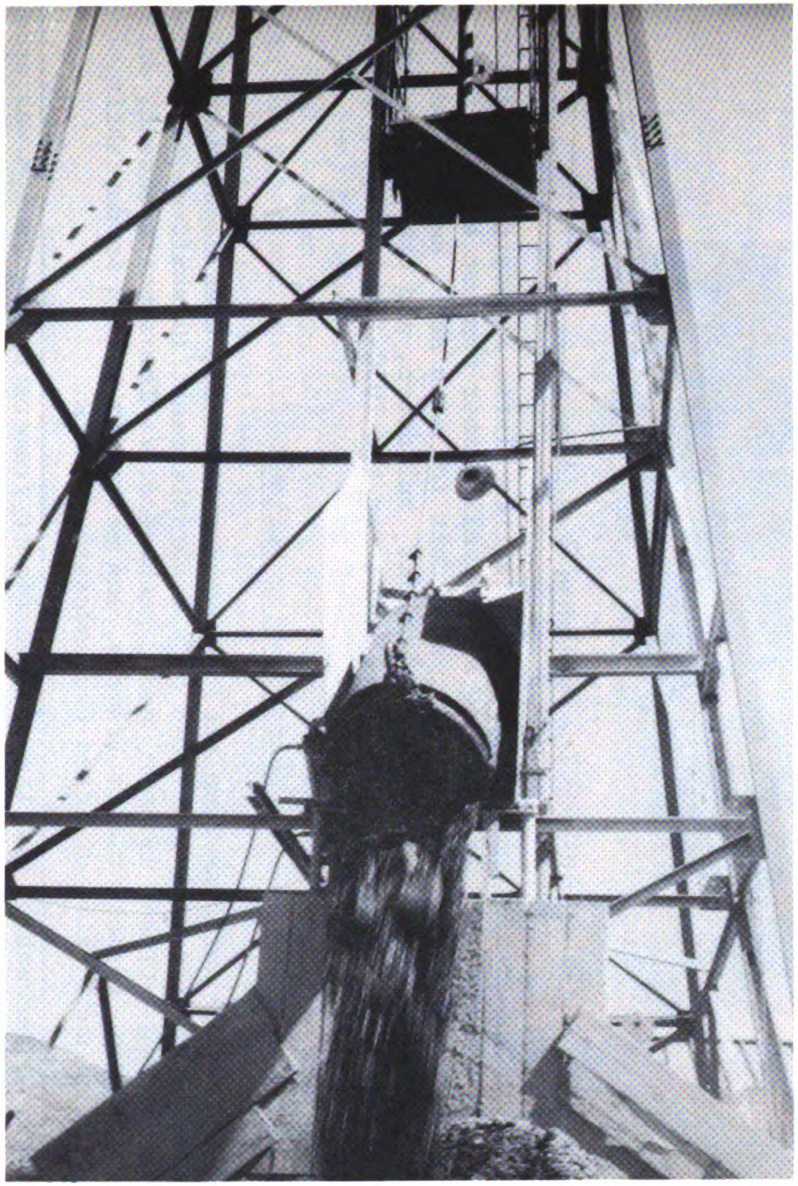

FIGURE 5. - Unloading Sinking Bucket.

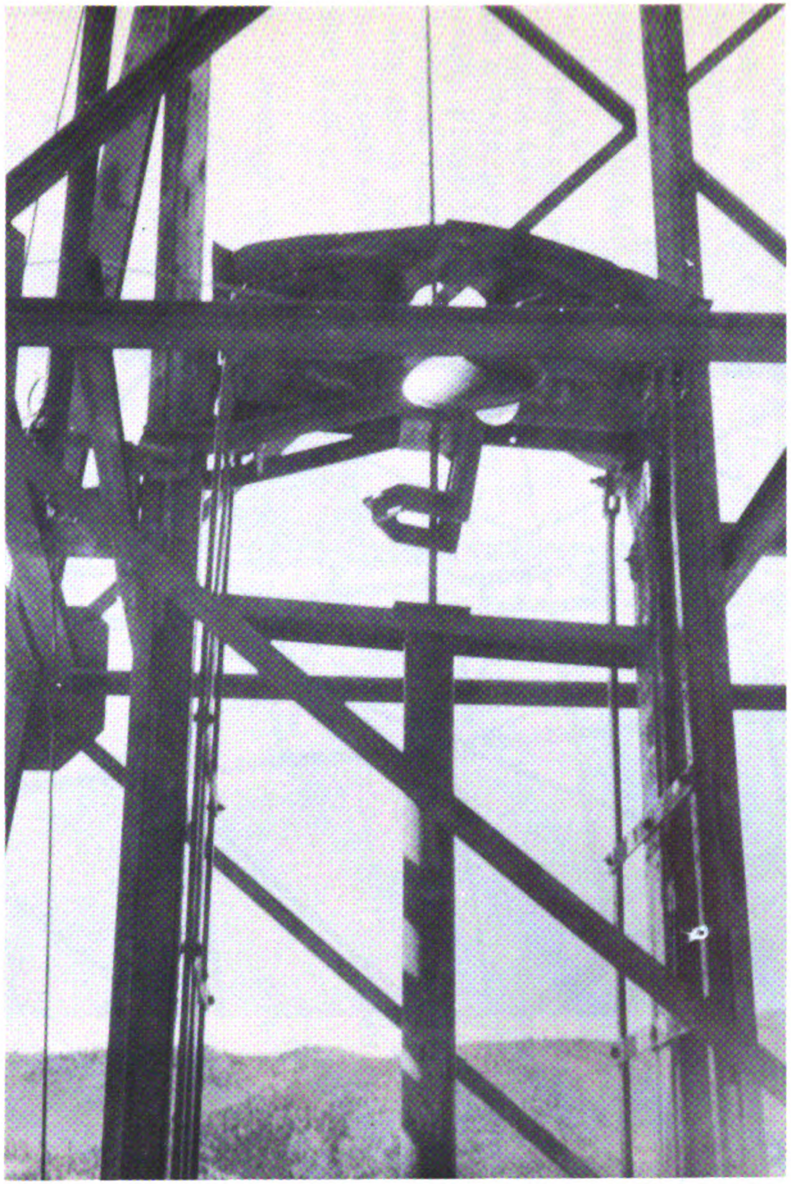

FIGURE 6. - View of Mechanism Holding Crosshead Cage.

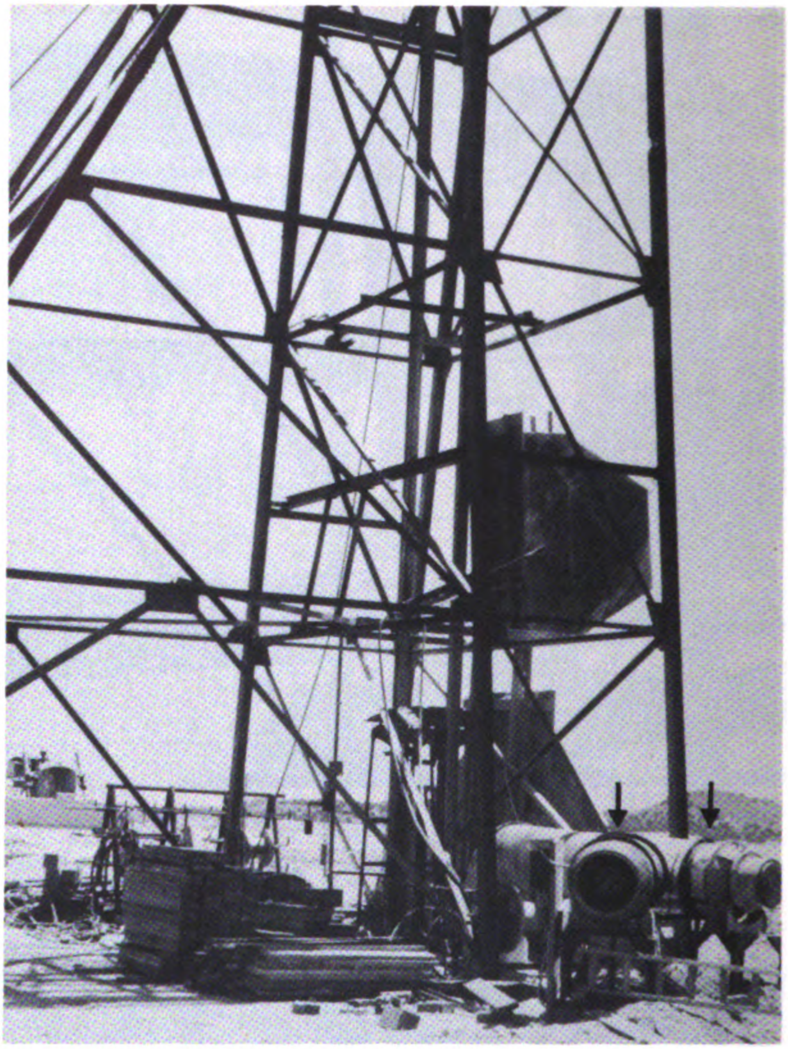

FIGURE 7. - Ventilation Fans (Arrows).

The timber-framing and machine shops at the Tintic Standard No. 2 shaft surface plant were used by the contractor. All timber was cut and framed at this shop and delivered to the shaft as a unit for each set. Repairs on drills, steel, bits, mucking machine, trucks, bulldozer, and other equipment were made at the machine shop. Steel items for the 1050-level dumping pocket were also made in the machine shop.

Shaft-Sinking Period

Preparatory work was completed by January 29, 1957, when regular shaft-sinking began. The crew consisted of a superintendent, 10 shaftmen, 3 hoistmen, 2 topmen, 2 timber framers, and 2 mechanics.[5] The superintendent, an extra shaftman, topmen, timber framers, and mechanics worked on day shift. A leadman on each shift directed the underground work.

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[5] About 40 percent of the time of the timber framers and mechanics was used on other projects.

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Outside timber measurements of the 2 1/2-compartment shaft are 15 feet 8 inches by 6 feet 4 inches (fig. 8). Two compartments are 5 feet square, and the manway is 3 by 5 feet. Timber sets are 6 feet apart. Hanging rods are of 7/8-inch round steel 3 feet 7 inches long, threaded on one end and bent with a 3-inch hook on the other end. Two hanging rods hooked together supported one end of an endplate. Four hanging-rod supports were used for each set.

Hoisting was done in the center compartment. The manway compartment contained a 4-inch aluminum high-pressure air line, a 3-inch discharge waterline, and a 2-inch water-supply line, all ends prepared for victaulic couplings. Manway platforms were laid every 12 feet, and ladders were placed between platforms (fig. 9). Electric cable wrapped on a spool was strung down the shaft for a 120-volt light. A permanent line was strung for 800 feet, where the second spool was installed. The working area was illuminated by a 150-watt globe.

Average work cycle of the sinking operation was as follows:

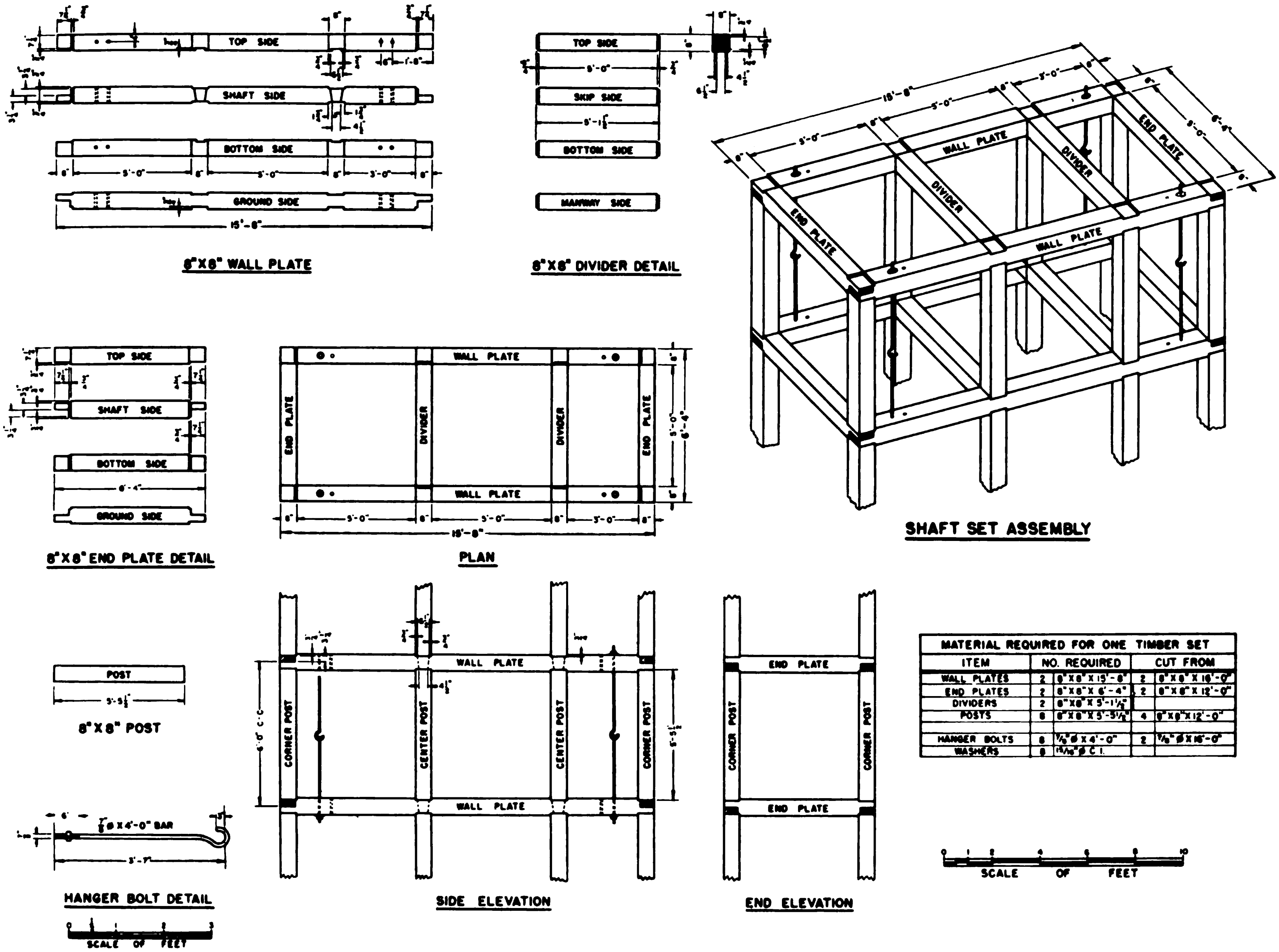
Drilling:	Minutes
Lower drills and clean bottom	15
Drill	150
Load holes, remove drills and air line	30
Smoke clearance (usually lunch time)	30
Mucking:	
Lower Cryderman mucker	15
Muck 12 to 15 buckets	120
Raise mucker, and prepare for timber	15
Timbering:	
Lower timber	15
Hang wallplate	30
Install endplates and blocking	45
Total	465

The timber panels were usually lagged while mucking was in progress. Generally two sets were installed every other day shift.

Drilling

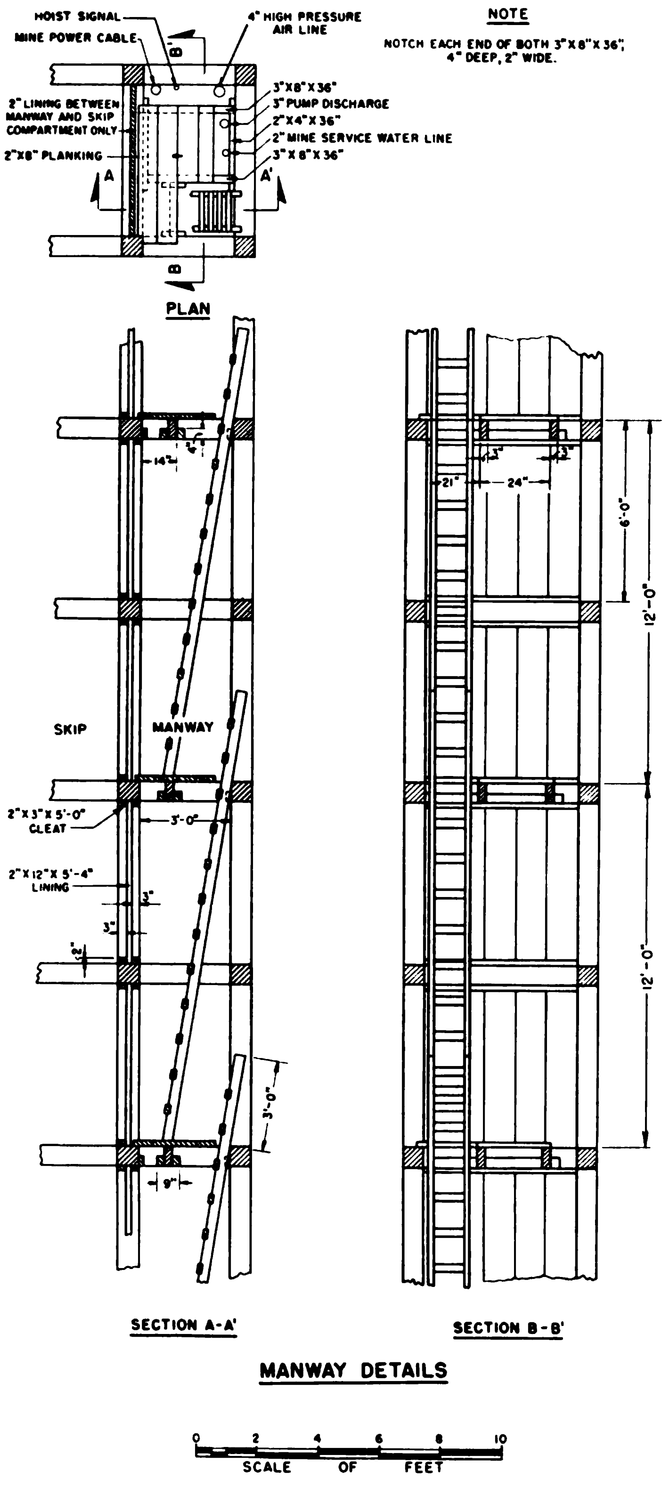
A sump or bench-type round of 20 to 26 holes was drilled to break half of the shaft bottom (fig. 10). Thus, one side of the bottom was always lower than the other and permitted drilling from a relatively clean, water-free surface. The side to be drilled was prepared by washing loose muck from the high side; compressed air also was used to clean the surface before drilling. One man attended to the drill steel, bits, and air hose; 2 men used 2 machines to drill the round. A round in rhyolite or dolomite consisted of 6 rows of 4 holes, each about 8 feet deep.

Drilling was done with handheld sinker drills weighing 56 pounds. The drilling rate in rhyolite and dolomite averaged about 1.4 feet per minute.



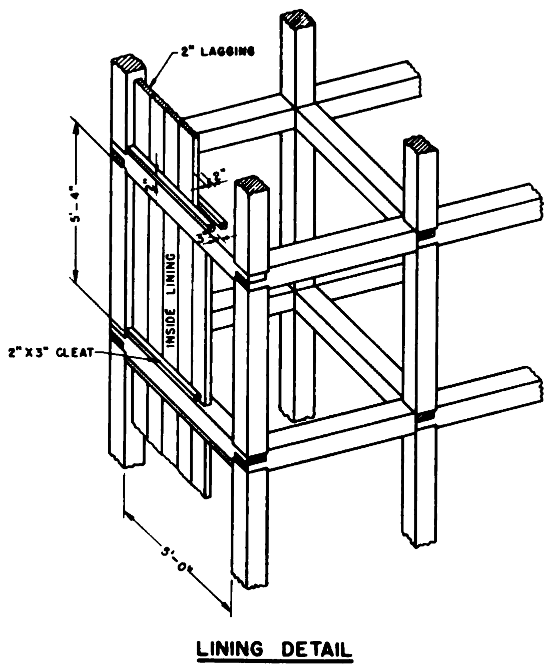
MATERIAL REQUIRED FOR ONE TIMBER SET				
ITEM	NO. REQUIRED		CUT FROM	
WALL PLATES	2	8"X8"X15'-8"	2	8"X8"X16'-0"
END PLATES	2	8"X8"X6'-4"	2	8"X8"X12'-0"
DIVIDERS	2	8"X8"X5'-1½"		
POSTS	8	8"X8"X5'-5½"	4	8"X8"X12'-0"
HANGER BOLTS	8	⅞"ø X 4'-0"	2	⅞"ø X 16'-0"
WASHERS	8	15/16"ø C.I.		

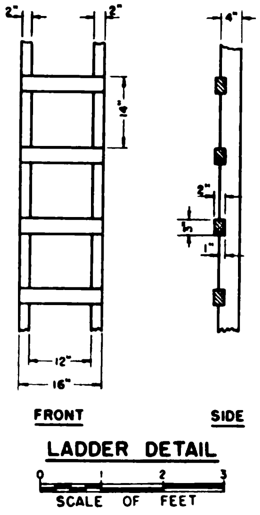
FIGURE 8. - Shaft-Timber Details.



NOTE

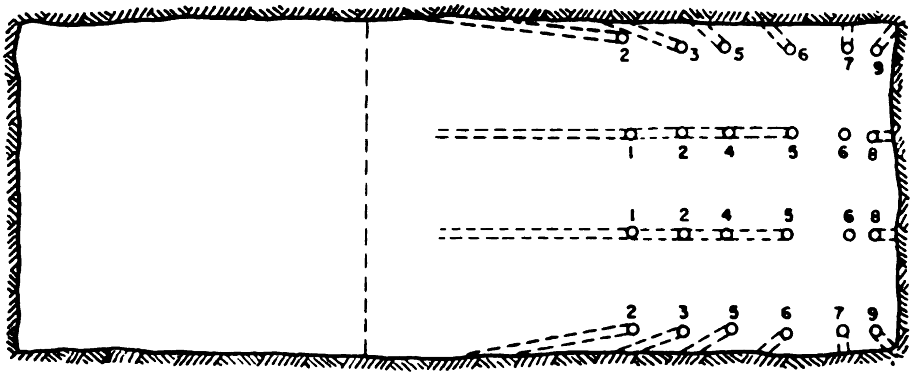
NOTCH EACH END OF BOTH 3"X8"X36", 4" DEEP, 2" WIDE.



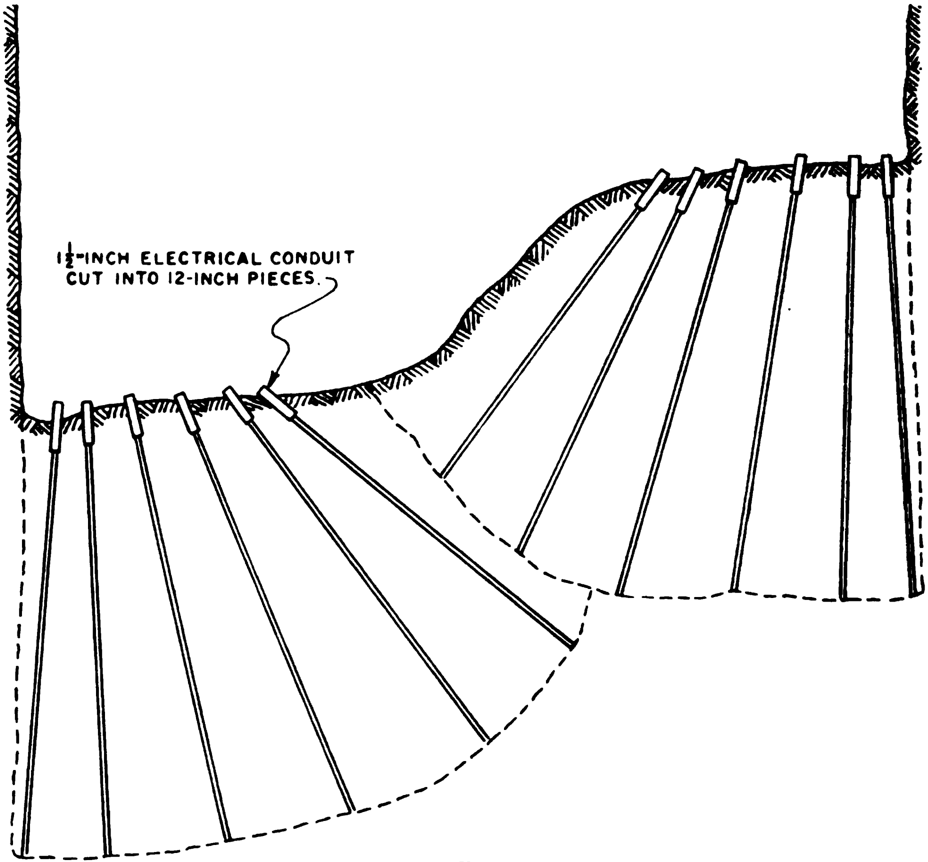


MATERIAL REQUIRED					
ITEM	PART	NO. REQUIRED		CUT FROM	
INSIDE LINING - 1 SET	LAGGING	54	2"X8"X5'-4"	18	2"X8"X16'-0"
	CLEAT	24	2"X3"X5'-0"	8	2"X3"X16'-0"
	CLEAT	8	2"X3"X3'-0"	2	2"X3"X12'-0"
MANWAY PLATFORM	FLOORING	2	2"X8"X2'-6"		
	FLOORING	2	2"X8"X4'-6"		
	JOIST	2	3"X8"X3'-0"		
	CLEAT	2	2"X4"X3'-0"		
	JOIST	1	3"X8"X1'-9"		
	CLEAT	2	2"X4"X9"		
MANWAY LADDER	RUNG	22	2"X3"X1'-4"		
	STRINGER	6	2"X4"X12'-0"	6	2"X4"X12'-0"
OUTSIDE LINING	LAGGING	66	2"X12"X6'-0"	66	2"X12"X6'-0"

FIGURE 9. - Manway and Lagging Details.



PLAN


1½-INCH ELECTRICAL CONDUIT CUT INTO 12-INCH PIECES.

SECTION

FIGURE 10. - Typical Bench, 24-Hole, Drill-Round.

Hexagonal, 7/8-inch drill steel, in changes of 2, 4, 6, and 8 feet, was used, with throwaway tungsten carbide insert bits. Bit gage was 1 1/2 inches for 2- and 4-foot steel, and 1 3/8 inches for 6- and 8-foot steel. Abrasive action of the ground caused excessive wear in the center of the bits and, after use for 3 or 4 rounds, the center of the bit was filled by welding (fig. 11). Usually 3 or 4 rounds were drilled after the welding before a bit was discarded.

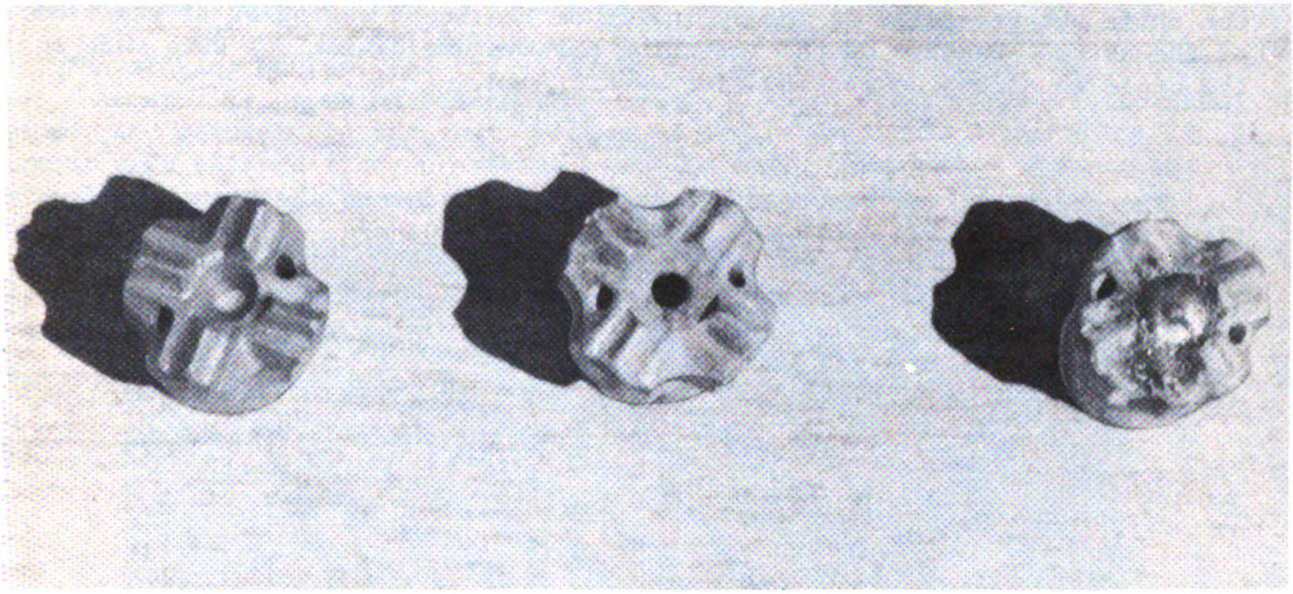


FIGURE 11. - New Bit, Worn Bit, and Welded Bit Good for Additional Use in 2 to 4 Drill Rounds.

A 5-gallon reservoir of drilling oil was installed on the air line to the shaft mucker, tugger, and sinker drills for lubrication. Drill water was obtained through the 2-inch waterline from the surface. Two pressure-reducing valves were installed on the waterline. A 1 1/2-inch hose was used for the air line and 3/4-inch hoses for the waterline to the sinker drills. Aluminum electrical conduit 1 1/2 inches in diameter was cut in 1-foot segments and used to collar each drill hole. These collars were prepared by the mechanics and, wherever possible, were retrieved from the surface muck pile.

Blasting

Electric primers of standard 1 to 9 delays were used for detonation. A 40-percent ammonia gelatin dynamite in 1- by 12-inch cartridges was used with the primer, and a 45-percent dynamite with no noxious fumes, in 1- by 8-inch cartridges, was used as the general explosive. An average round for half of the shaft required about 80 pounds of explosive. Primers were wired in series, and the circuit was checked with a galvanometer before being connected to a 2-wire, 440-volt blasting circuit extending to the surface. A special blasting switch was used for the detonation.

Because the timber was 25 to 35 feet above the bottom of the shaft, no special provisions were required for protecting it in blasting. The lowest part of the mucking machine was always 35 to 45 feet away from the face

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being blasted. Rhyolite, limestone, and dolomite usually broke into small pieces, whereas the silicified limestone, dolomite, and quartzite broke into pieces as large as 10 inches on a side.

Fumes from the blasting were exhausted for about 20 minutes through a 30-inch ventilation pipe, and fresh air was blown into the bottom of the shaft during the remainder of the working cycle. Blasting was done any time during the shift but generally at the beginning of the lunch period or at the close of the shift. Because of the incentive pay system, deviations were made in the cycle to allow the maximum time underground.

Mucking

The shaft-sinking featured the use of the Cryderman shaft mucker (fig. 12). This machine was designed and first used in Canada. Several machines are now being used in the United States.

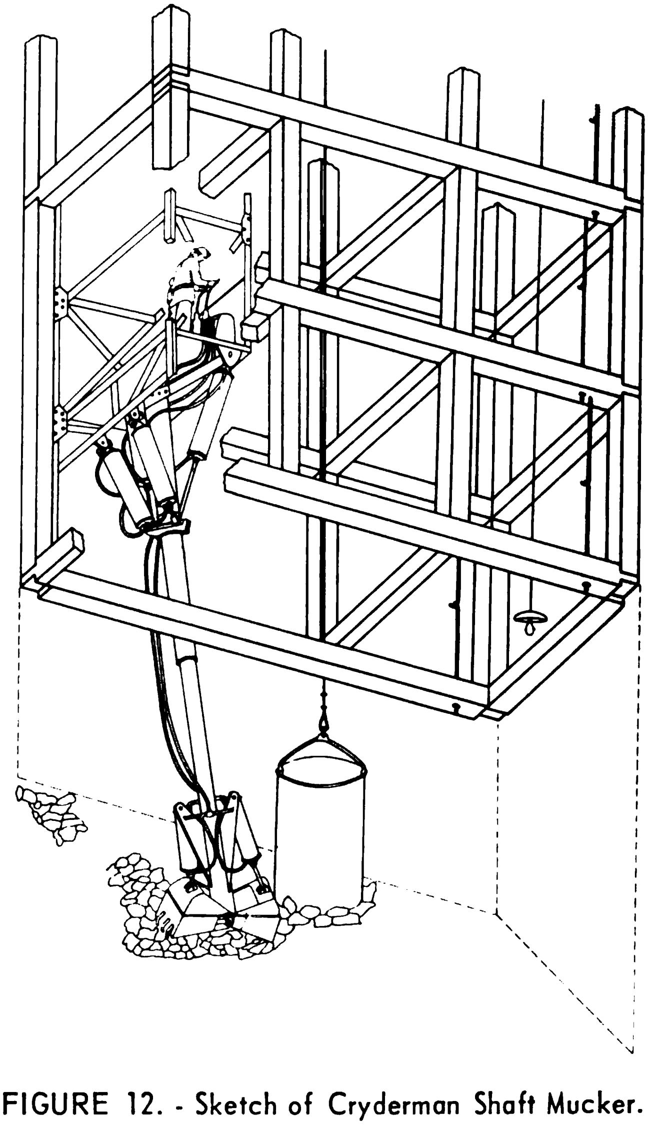

FIGURE 12. - Sketch of Cryderman Shaft Mucker.

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The shaft mucker occupied the manway compartment. In the lowering operation 1 man remained at the mucker controls, 1 man operated the air tugger hoist that lowered the machine, and a third man assisted in keeping the bull hose free of entanglements. The cage of the machine was secured to the wallplates by chains before mucking started. Usually 10 to 15 minutes was required to lower the machines to mucking position. One man operated the mucker, and the other shaftmen installed lagging and dividers. Men were not allowed in the bottom of the shaft while mucking was in progress.

The sinking bucket measures 44 by 66 inches and has a volume of 53 cubic feet. About 2 1/2 tons of broken rock can be loaded into the bucket, hoisted, dumped, and returned to the shaft bottom in 5 to 7 minutes. About 12 to 15 buckets were hoisted from an average round for half the shaft. The mucking and hoisting part of the cycle consumed about 2 hours.

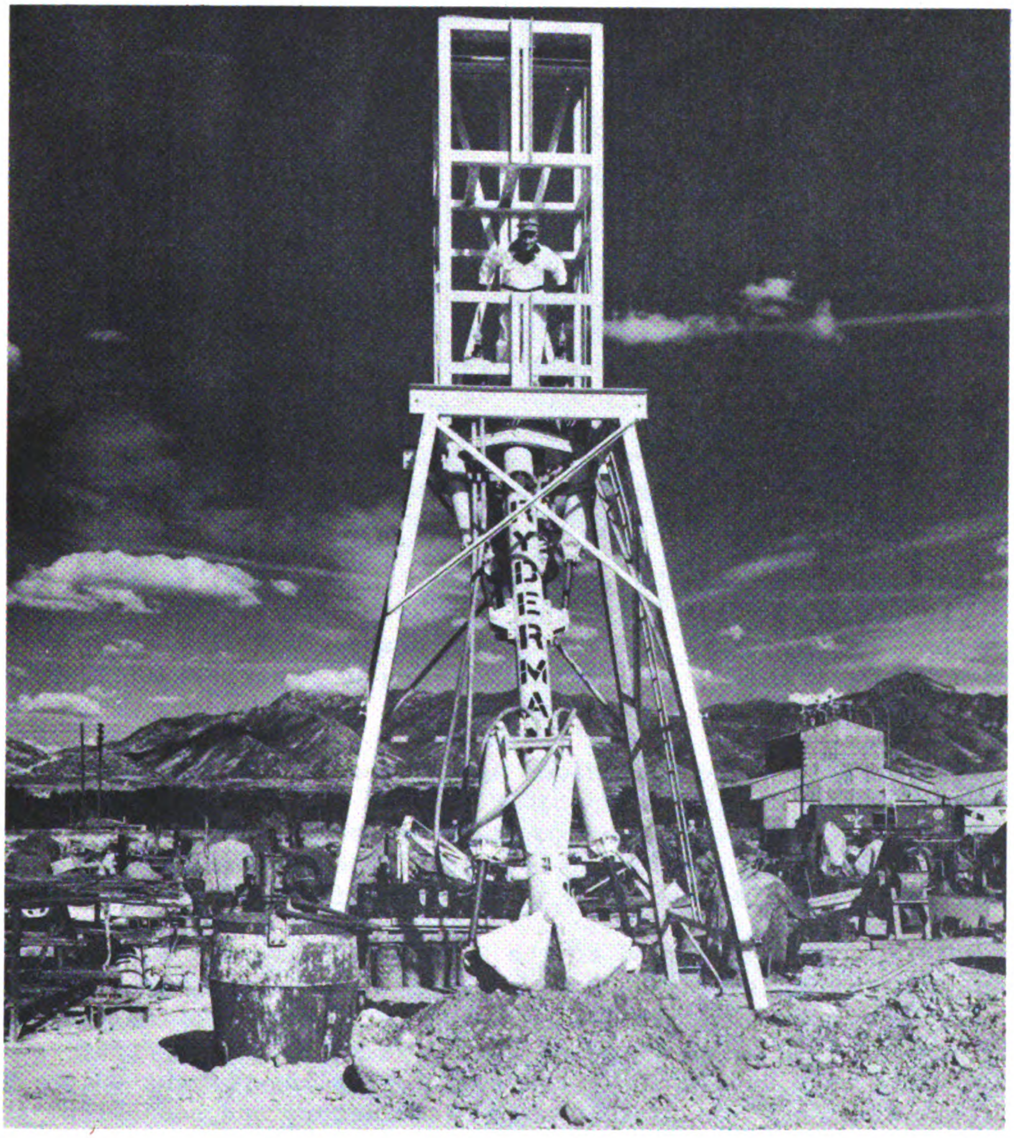

FIGURE 13. - Surface View of Shaft Mucker.

The Cryderman shaft mucker features positive placing and force closing of the clamshell. The machine consists of an angle-iron frame and the cage connected to a telescopic boom that has a 3/8-cubic yard clam bucket. The cage is made in 2 sections, each 10 feet long. A tugger hoist is anchored on the top of the upper section of the cage. The lower cage contains the operator platform and controls. The mucker was suspended from a 10-inch steel beam in the shaft by a 6-strand cable-pulley arrangement. The steel beam was chained securely between a divider and the endplate. The cage was made to fit the manway compartment by welding angle-iron skids on the front side, enabling the cage to slide up or down easily in the compartment. The telescopic boom is attached to the cage by a gimbal joint; an air cylinder within the boom activates its extension for 14 feet 8 inches, or to an overall length of 31 feet 8 inches. The retracted length is 17 feet. Two air cylinders, which are mounted at the front and on each side of the gimbal joint, control the swing of the boom from side to side. The maximum swing distance of the clam bucket is 14 feet to each side. Two air cylinders, at the back of the boom and connected to the cage, control the forward angular raising or lowering of the boom. The clam bucket is opened or closed by two air cylinders mounted on each side of the boom.

The operator stands on a platform at the bottom of the lower cage, where he can observe the bottom of the shaft, and the machine is controlled by two "joystick" levers connected to multiple directional valves (fig. 13). With the forward or backward movement of the lever at the right, the telescopic boom is extended or retracted. Sideward motion of this lever opens or closes the clam jaws. Forward or backward movement of the left lever controls the raising or lowering of the boom, and sideward movement controls the side motion.

The machine weighs 7,600 pounds, requires 500 cubic feet of compressed air a minute, and resembles a human arm, reaching forward and clutching a handful of muck. In sinking the Burgin shaft the machine was used to bail water into the sinking bucket. The operator frequently used the clam to pick up the bucket and place it in a more advantageous position in the shaft bottom. While a bucket was being hoisted, the muck from the far end of the shaft was transferred by the machine to the near side. Usually a small depression was maintained in the muckpile where the bucket was placed. The bottom of the shaft was cleaned by the machine, and no hand mucking was necessary. Operators for the machine were trained in 3 or 4 days.

At first shaftmen were prejudiced against use of the machine. During the first month of shaft sinking an operator dropped the boom, and repairs were necessary. Having to use the other methods of machine mucking convinced the shaftmen of the versatility and convenience of the Cryderman shaft mucker, and the men later regarded the machine highly efficient.

The hoisted muck was dumped to the ground. An average of 3 hours was required for a diesel bulldozer to move the muck accumulated by three shifts over the edge of the dump (fig. 14). Toward the end of the shaft-sinking phase of the work the volume of waste became so large that a front-end loader and a truck were used to transport the muck to the edge of the dump. These methods of handling surface waste proved satisfactory and economical and removed the need for a surface man at the shaft collar during the afternoon and graveyard shifts.

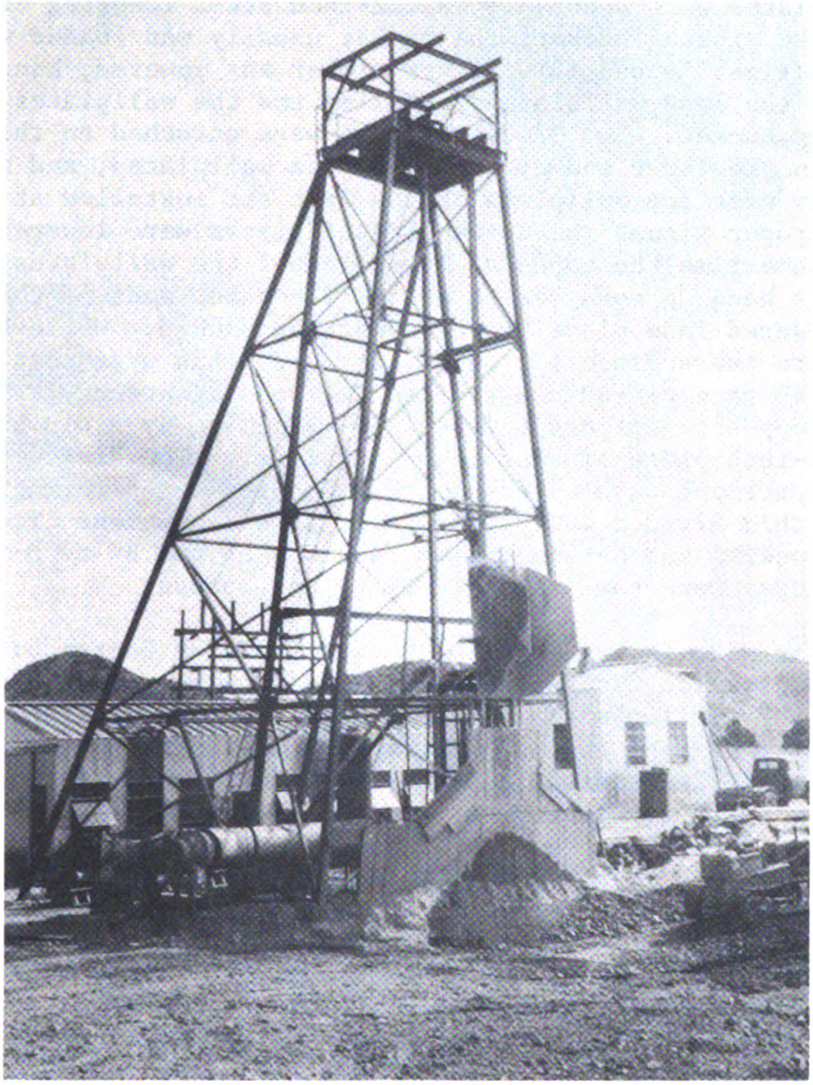

FIGURE 14. - Disposing of Waste.

Timbering

Timber was framed according to specifications of the Bear Creek Mining Co. (fig. 8). All timber is No. 1 mining grade, rough, full-dimension, untreated Douglas fir; skip guides are spruce. Hanging rods are 7/8-inch round steel threaded on one end and hooked on the other. Bearing sets were placed every 150 feet and 2 sets below the 1050 station.

All shaft-support timber is 8 by 8 inches in cross section, except bearing timbers, which are 8 by 12 inches (fig. 4). The outside lining of the shaft is 2- by 12-inch by 6-foot planking, and the inside compartment lining is 2 by 8 inches by 5 feet 4 inches.

Two sets of timber usually were installed every other day shift, but occasionally 1 or 2 sets were installed on other shifts, according to need.

The longwall plates were secured by a 1/2-inch steel lowering clamp and suspended below the sinking bucket; the bucket usually was loaded with lagging and endplates (figs. 15 and 16). After timber was lowered, hanging rods were placed in both the last wallplates installed and the wallplates suspended below the sinking bucket. Two 3/4-inch ropes were attached to the hook of the hanging rods on the lower end of the suspended wallplates, and the other end wrapped loosely over the wallplate of the last set installed at the hanging rod. At the proper signal the suspended wallplates were lowered by the hoistman. At the same time the ropes at lower end of the wallplates were pulled upward, and the hanging rods were hooked. The other ends of the hanging rods were merely lowered into place by the hoist and hooked. While the bucket was being hoisted to the surface for posts, the endplates were installed. The eight posts were soon placed and the hanging rods tightened. The set was alined in the opposite corners before final blocking by a plumb line the width of a 3/4-inch piece of wood from the timber. The divider separating the manway compartment usually was omitted to provide operating space for the shaft mucker; this divider was placed later at a convenient time in the working cycle. Blocking was obtained from remnants of the 8- by 8-inch timber, and 12-inch wedges were sawed from 2- by 4-inch boards.

Timber sets were installed 8 to 30 feet from the bottom of the shaft. Usually 4 men installed 2 sets, not including lagging, in 4 hours. Lagging was placed by the available shaftmen, generally during mucking. Occasionally a complete shift was used to install lagging, dividers, manway platforms, ladders, and pipe. The shaft ultimately was timbered to the bottom; the last set has 12-foot posts for convenient removal if the shaft should be deepened.

Pumping

Water began seeping into the shaft bottom at a depth of about 180 feet, and at 200 feet bailing was begun. Occasionally the water became deep enough for direct bailing by the sinking bucket. Later a pneumatic sump pump was used to fill the bucket, which was then hoisted and emptied.

At a depth of approximately 300 feet a water-bearing zone was found that, after the first surge, yielded about 20 gallons of water a minute. A concrete sump was constructed around the outside of a set of timber to facilitate collecting the water. This ring dam is about 1 foot deep and 1 1/2 feet wide. A low-volume, high-pressure, horizontal triplex pump was used to pump the water to the surface through a 2-inch line. The ring dam proved to be successful, but some water seeped into the shaft, making it necessary for the shaftmen to wear water-repellent suits over their clothing.

1050-LEVEL STATION

An excavation for station and loading pockets was cut from the south side of the shaft at 1,050 feet, and as the shaft was being sunk 3 headings were started to the west, south, and east. An air tugger-scraper was used for mucking the drift headings that extended only 15 feet from the shaft.

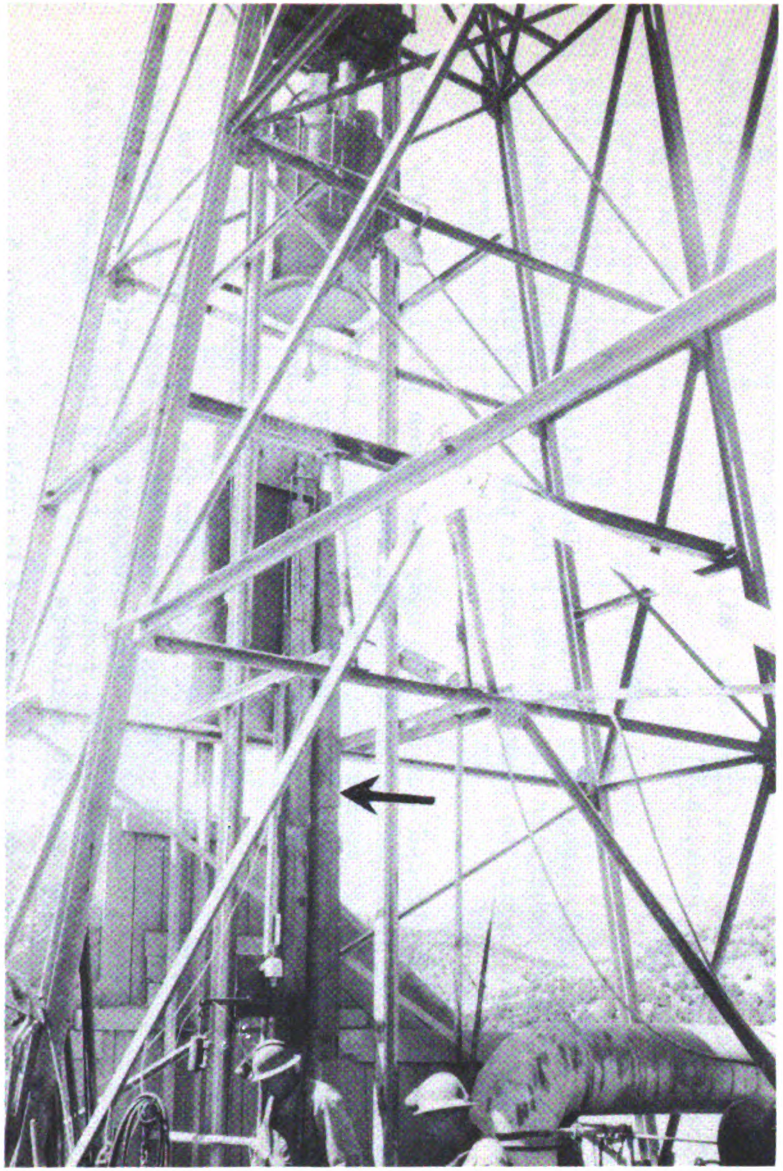

FIGURE 15. - Wallplates (Arrow) Suspended Below Sinking Bucket.

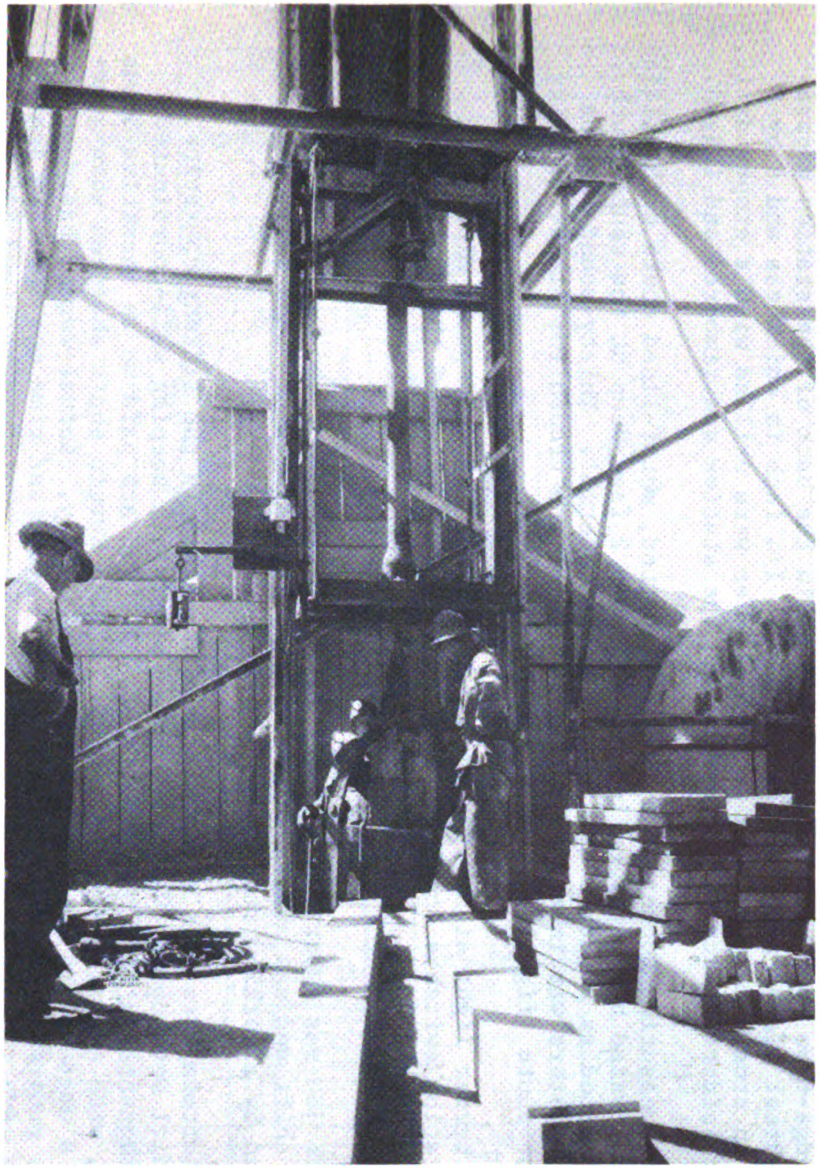

FIGURE 16. - Lowering Timber in Sinking Bucket; Wallplates for Next Set in Foreground.

Wedge-type roof bolts first were used in the back of the station excavation. Steel plates used with the bolts are 1/4 inch in thickness and 8 by 8 inches in cross section. The roof-bolt holes were drilled with a stoper drill. Later considerable scaling occurred, and the station was timbered and lagged.

The measuring pocket is a timber-supported, metal-lined chute with sliding gates activated by an air cylinder. A trench 2 feet deep at the chute mouth was excavated as a pocket for dumping mined material. Thirty-pound rail on 15-inch centers was installed on the bottom of the trench for slusher loading into the chute (fig. 17).

A buzzer light signal system was installed, and a 20-pound mine track with station switches completed the shaft-sinking phase of the work.

SUPERVISION AND LABOR

The job was supervised closely by a superintendent who worked regularly on day shift and was available on other shifts as needed. Each shift was directed by a working leadman.

Shaftmen were able to do all jobs necessary in the sinking operation. Centennial Development Co. has been successful in keeping well-coordinated crews together on this and other jobs. All men are paid on an incentive bonus system, with a guaranteed daily wage. At the Burgin shaft shaftmen were guaranteed a wage of $18.75 and leadmen, $19.75 a day. Actual wages, based on footage progress, exceeded the guaranteed wages, and time not spent in shaft-sinking work was not applied against the bonus. Hoistmen received $18.75 a day plus one-third of a shaftman's bonus. The wages of topmen, timber framers, and repairmen ranged from $17.14 to $19.75 a day.

The company had no labor troubles. All men are members of a local of the United Steelworkers of America.

SAFETY

State safety regulations were observed. In addition, men were not permitted to work above others in the bottom of the shaft, and the hoistman indicated the approach of the sinking bucket to the working area by a blinking light.

The men are experienced miners, and many had taken previous safety training. Two lost-time accidents occurred during the shaft-sinking operation. The operator of the shaft mucker lost 1 day because of fractured ribs when the mucking machine was dropped 15 feet the first day it was put in operation; a second man missed 2 weeks of work because the drill fell on his foot.

COSTS AND PERFORMANCE DATA

Costs and performance data are presented for the basic phases of the shaft-sinking operation. Data covering administration, accounting, amortization, taxes, insurance, preliminary work, equipment costs, equipment depreciation, equipment maintenance, pipe, concrete, tools, headframe, mechanical supplies, and other items are not available.

Cost and performance data are presented in tables 1 through 5.

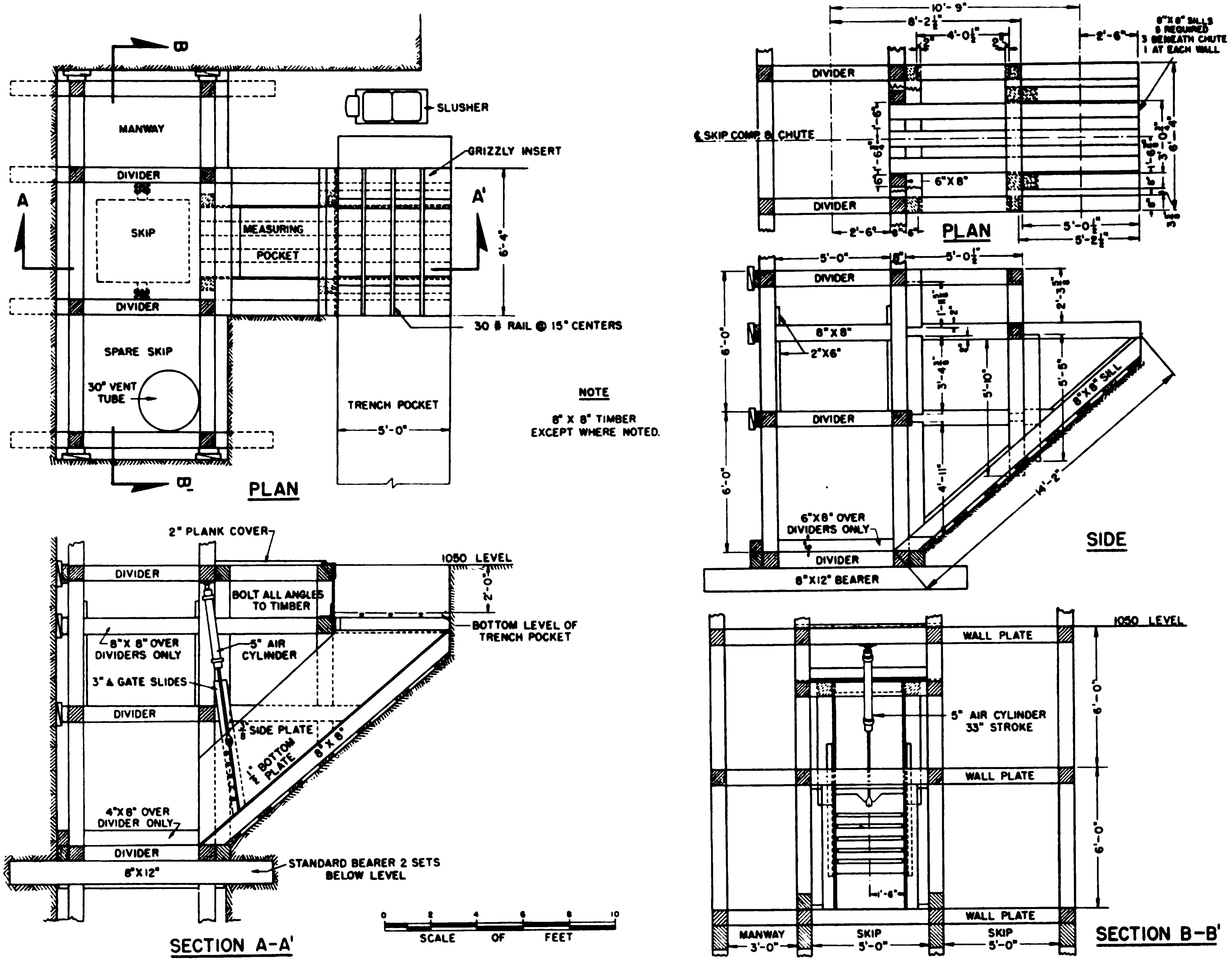

FIGURE 17. - 1050-Level Loading-Pocket Details.

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TABLE 1. - Personnel

	Number a shift	Number of shifts	Total for 24 hours
Underground:			
Supervision	1/2	1	1/2
Labor	3-1/3	3	10
Surface:			
Supervision	1/2	1	1/2
Hoisting	1	3	3
Topmen[1]	2	1	2
Timber framing[1]	2	1	2
Mechanics[1]	2	1	2
Total			20

[1] About 40 percent of the time of 1 topman, timber framers, and mechanics was chargeable to other company projects.

TABLE 2. - Typical working cycle, in hours, by shifts[1]

Day		Afternoon		Night	
Underground:					
Muck	3	Drill	2-1/2	Drill	1
Timber (2 sets)	4-1/2	Blast	1	Blast	1
Install pipe	1/2	Muck	3	Muck	3
		Drill part of round	1-1/2	Drill Blast	2 1
Surface:					
Hoist	8	Hoist	8	Hoist	8
Muck disposal	4				
Haul timber	4				
Frame timber	8				
Repair equipment	8				

[1] Includes lunchtime and miscellaneous delays.

TABLE 3. - Labor and material costs per foot

Working time, February 1 to June 30, 1957; shaft interval, 71 to 998 feet, or a total of 927 feet; shaft timbered, 927 feet.

	Labor	Supervision	Drill steel and bits	Power	Explosives	Timber	Other supplies	Total
Drilling	$12.92	$0.43	$1.60	$0.73				$15.68
Blasting	4.84	.24			$7.03		$0.20	12.31
Mucking	5.68	.28		1.02			[1] 1.47	8.45
Ventilation	.28	.01		.09				.38
Pumping	.44	.03		.05				.52
Timbering	15.16	.64				$10.34	4.00	30.14
Hoisting	7.53	.10		.52				8.15
Rock disposal	.76	.03					.62	1.41
Timber framing	2.50	.10						2.60
Mechanical repairs	2.56	.10						2.66
Total	$52.67	$1.96	$1.60	$2.41	$7.03	$10.34	$6.29	$82.30

[1] Shaft-mucker royalty, $0.40 per cubic yard.

TABLE 4. - Costs in units of labor and supplies

Time covered, February 1 to June 30, 1957; footage covered, 927 feet.

Labor	Man-hours per foot	Power and supplies	Units per foot
Drilling	2.84	Explosives pounds	21.712
Blasting	1.063	Primers each	6.606
Mucking	1.240	Timber board feet	110
Timbering	3.055	Hanging rods feet	5.4
Hoisting	2.744		
Muck disposal	.355	Drill bits bits	.3
Pumping	.083	Power kw-hr.	575
Ventilation	.056		
Guides	.114		
Manway platforms and loaders	.154		
Surface labor	2.744		
Supervision	.914		
Total	15.362		

TABLE 5. - Performance record and general data

Progress:		
Total time worked in shaft	days	142
Average progress per 24 hours	feet	7.75
Total shifts (shaft)		381
Total shifts (pocket and station)		33
Total rounds (half of shaft bottom per round)		303
Progress per round	feet	3.63
Average increased cycle time per 100 feet of advance	percent	.69
Drilling:		
Total labor	man-hours	3,124
Holes drilled per round		24
Distance drilled per round	feet	190
Distance drilled per man-hour	do.	19
Distance drilled per foot of shaft advance	do.	52.34
Drill steel used per round	pieces	8
Drill bits used per round	bits	8
Drill steel consumed per round		1/
Drill bits consumed per round	bits	1.14
Blasting:		
Total labor	man-hour	1,170
Explosives consumer per foot	pounds	21.11
Explosives per cubic yard	do.	5.41
Mucking:		
Total labor	man-hours	1,365
Effective excavation	cubic feet	110,000
Effective excavation per bucket	do.	20.22
Effective excavation per man-hour	do.	80.6
Timbering:		
Total labor	man-hours	3,366
Number of sets		181
Labor per set (154 sets)	man-hours	18.38
Timber per set (inside lining between compartments not included)	board feet	662
Concrete for collar section	cubic yards	3.2
Total depth concreted	feet	10
Shaft equipment:		
Installing guides	man-hours	170
Installing pipe	do.	140
Bearer sets (8 sets) each	do.	24
Ventilation pipe	do.	61
Pockets and station excavated:		1
Labor stations, drift stubs, and pockets	man-hours	1,584
Miscellaneous work:		
Ring dam	man-hours	20
Mucker repairs	do.	128
Hoist cable	do.	16

1/ Negligible.

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